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(54) Title: STENT HAVING ANTIMICROBIAL AGENT
(54) Titre: EXTENSEUR POURVU D'UN AGENT ANTIMICROBIEN

(57) Abstract

A medical stent having an inorganic antimicrobial agent on a surface, the agent preferably being a zeolite. The stent can be of metal or a polymer and the agent being in a coating that is applied to one or both of the surfaces of the stent. The stent can be of a polymer resin incorporating the agent.

(57) Abrégé

L'invention concerne un extenseur médical dont une surface est pourvue d'un agent antimicrobien inorganique, l'agent étant de préférence un zéolite. L'extenseur peut être fait d'un métal ou d'un polymère et l'agent peut se présenter comme un revêtement appliqué à une ou aux deux surfaces de l'extenseur. L'extenseur peut être en résine polymère avec l'agent incorporé.

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(57) Abstract

A medical stent having an inorganic antimicrobial agent on a surface, the agent preferably being a zeolite. The stent can be of metal or a polymer and the agent being in a coating that is applied to one or both of the surfaces of the stent. The stent can be of a polymer resin incorporating the agent.

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Description

STENT HAVING ANTIMICROBIAL AGENT

Field of the Invention

The invention relates to a medical stent having antimicrobial properties.

Background of the Invention

Stents are devices widely used in the medical field. For example, there are coronary and peripheral artery stents made of metal, such as stainless steel, NiTi or tungsten. Typical of these are of the type shown in U.S. patent 5,690,670. These stents also can be of metal coated with a polymer, such as polyurethane, or coated with a material such as silicone rubber. Typical of these are stents shown in U.S. Patent 5,713,949. Biliary, +esophageal, urinary and urethral stents often are of polymeric material. Stents of a polymer material are shown in U.S. Patents 5,713,949 and 5,607,467.

Most, if not all, of such stents are subject to contact with body fluids, such as blood, and with body tissue, such as arterial vessels. The materials contacting the stent are potential sources of contamination by bacteria. Also, the stent itself is a potential site for bacteria growth. Therefore, it would be desirable to provide the stent with antimicrobial properties. That is, it would be desirable that bacteria in the body fluids and tissue contacting the stent are killed. Providing the antimicrobial properties preferably should be done in a manner which does not increase build-up of solid materials deposited on the stent and, more preferably, should reduce such build-up. Also, providing the stent with antimicrobial properties should

not adversely affect the stent deployment characteristics or its mechanical properties.

The general subject of attempting to provide antimicrobial action for medical type products to be used in the body has been considered. For example, U.S. Patent 5,906,466 describes an antimicrobial composition comprising antimicrobial silver compounds deposited on a physiologically inert oxide support material. In Japanese patent abstract No. 08041611 an alloy exhibiting antimicrobial properties is disclosed.

Brief Description of the Invention

The present invention relates to a medical stent having antimicrobial properties. For a metal stent, in one embodiment a coating of a material with the antimicrobial agent is applied to the stent. For example, for the metal stent, the coating is of an adhesive type material, such as a hydrophilic polyurethane, which contains the antimicrobial agent. In another embodiment of a metal stent, the agent is applied to the metal stent as a powder coating. The coating can be applied to either both of the stent inner and outer surfaces.

For polymer stents, the agent can be blended into the polymeric resin that forms the stent. Thus, antimicrobial agent is present on both the stent inner and outer surfaces. Here also, a stent of resin material can have a coating containing the agent applied to one or both of its inner and outer surfaces.

In a preferred embodiment of the invention, the antimicrobial agent is of inorganic material, preferably a zeolite.

Objects of the Invention

It is therefore an object of the invention to provide a medical stent having antimicrobial properties.

Another object is to provide a medical stent one or both of whose inner and outer surfaces is coated with an inorganic antimicrobial

agent.

A further object is a medical stent containing a zeolite as an antimicrobial agent.

Still an additional object is to provide a medical stent made of resin containing an inorganic antimicrobial agent.

Yet another object is to provide a medical stent having a coating containing an inorganic antimicrobial agent.

Brief Description of the Drawings

Other objects and advantages of the present invention will become more apparent upon reference to the following specification and annexed drawings in which:

Fig. 1 is a view of a typical medical stent of metal; and

Figs. 2 and 3 respectively show a plan view of a blank of material for a stent and a stent made from the blank.

Detailed Description of the Invention

Fig .1 shows a metal stent of the type disclosed in U.S. Patent 5,690,670. This is illustrative of any type of metal stent with which the present invention can be utilized. The stent 160 of Fig. 1 is of the expandable type and is shown in a non-expanded state positioned on the distal end of a balloon expandable segment 162 of a guide wire 164. The stent 160 is fabricated from a suitable material such as stainless steel, NiTi, tungsten, Ti-Nb-Zr alloy or any other suitable material. The stent illustrated is designed so that it can be collapsed over a balloon segment of a balloon catheter.

The stent is positioned within a segment of a tubular body conduit 165, a blood vessel for example, to be propped open. Expansion of the balloon 162 expands the stent 160 radially outward up to the blood vessel wall 166 so that means for gripping soft tissue, such as barbs (not shown), on the outer surface of the stent 160, engage and grip blood vessel

tissue to anchor the stent 160 in position. The balloon 162 is then collapsed and removed leaving the stent. In this way, the blood vessel is permanently propped open. As seen, the stent is in a position where it is contacted both by blood and body tissue.

In accordance with the invention one or both of the stent inner and outer surfaces has a coating 200 of a material containing an antimicrobial agent, which is described in detail below. It is preferred that at least the outer surface be coated with the material containing the agent since this comes into contact with the body tissue. The process for coating and the material are described below.

The metal stent described in Fig. 1 for a blood vessel is only illustrative of the type of stent with which the subject invention can be employed. It is also applicable to urinary, gastrointestinal, and other stent applications. The stent can be of any shape, size and metal suitable for the application.

Figs. 2 and 3 show a stent of the type disclosed in U.S. Patent 5,713,949. As shown from Fig. 2, the stent starts as a flat piece of material 1 that has a top edge 2, a bottom edge 3 and ends 4 and 5. The piece 1 includes rows of slots 6, 7 which are offset from each other. The material of piece 1 is a resin, such a polyethylene, polyurethane, polytetrafluoethylene, silicone, block co-polymers of polyurethane and other suitable resins. These materials can be molded in a suitable die to produce the desired shape and slots 6, 7.

As seen in Fig. 2, the piece 1 is formed into a cylindrical stent with the edges 2, 3 attached together by any suitable means such as, for example, by surface fusing, ultrasonic welding or any other suitable technique. It should be noted that the material for piece 1 can be of metal. Here, the slots 6, 7 can be formed by laser etching or other suitable technique.

For stents of a polymer material the agent can be incorporated directly into the resin used to make the stent. A coating containing the agent

also can be applied to one or both of its surfaces.

Processes for making the different types of stents are described below.

Coated Stents - For a metal stent, the inorganic antimicrobial agent preferably is applied as a coating. A coating with the agent also can be applied to a stent of polymeric material, such as of Figs. 2 and 3. In either case, the coating must be adherent and flexible, the latter to accommodate flexing, bending and compression of the stent. Typical thickness for the coatings are from between about 1 - 15 microns, preferably, between about 1 - 10 microns and most preferably between about 1 - 5 microns.

Coatings of a polymer containing the agent are preferred for both the metal and polymeric stents. These can be bonded to the stent, that is, the coating is effectively adhesively bonded to the stent. The polymers for the coating can be of silicone rubber and hydrophilic polymers. A preferred coating can be of, for example, a hydrophilic polymer such as hydrophilic polyurethane or a hydrophilic polymer material having a lubricious property, such as shown in U.S. Patent 5,731,087. The antimicrobial agent preferably comprises zeolite ceramic particles mixed with the coating material. That is, the zeolite particles are blended in the desired amount into the coating material.

The agent particles comprise by weight of the coating between about 0.1% - 100% , more preferably between about 0.1% - 75% and most preferably between about 0.5%-50.0%. The size of the particles of the agent is preferably about 1.0 micron in nominal diameter.

The coating with the agent is applied by any suitable technique, such as spraying, painting or dipping the metal or resin stent into the coating material. This can be done either while the material piece forming the stent is flat or after it has its cylindrical shape. By using painting or spraying the coating with the agent can be applied to only one of the stent inner or outer surfaces. Heat and/or pressure is applied and roughening or etching of the surface is performed as needed depending upon the stent and coating

materials.

1. Polymeric stent with coating:

resin for stent	any suitable resin such as polyurethane, polyvinylchloride
coating	Hydrophilic polyurethane, silicone rubber adhesives
agent	0.1 to 5.0 wt% Ag in zeolite
wt%	0.1 to 100.0, more preferably 0.5 to 75.0 and most preferably 1.0 to 50.0 of agent in the coating
size of agent particles	1.0 microns

2. Metal stent that is coated:

stent material	NiTi, stainless steel, Ti-Nb-Zn, tungsten, tantalum
coating	hydrophilic polyurethane, silicone rubber adhesives
agent	0.1 to 5.0 wt% in Ag in zeolite
wt%	0.1 to 100.0, more preferably 0.5 to 75.0 and most preferably 1.0 to 50.0 of agent in the coating
size of agent particles	1 micron

3. Metal stent with resin coating containing antimicrobial agent:

stent material	NiTi, stainless steel, TiNb-Zn, tungsten, tantalum
coating	hydrophilic polyurethane, silicone rubber adhesives.
agent	0.1 to 5.0 wt% Ag in zeolite

	wt%	0.1 to 20.0, more preferably 0.5 to 10.0 and most preferably 0.5 to 5.0 of agent in the coating
5	size of agent particles	1.0 micron

Metal stents 2 and 3 above involve coating the metal with the polymer leaving the spaces 6, 7 of Figs. 2 and 3 between the metal struts free. In contrast, metal stent 3 above is a metal stent that is completely covered by a polymer containing the zeolite.

For a metal stent, a powder coating process also can be used to apply the coating containing the antimicrobial agent. A powder coating process usually comprises the basic steps of cleaning the metal, electrostatically spraying the powder onto the metal, and baking. One or both of the stent surfaces can be powder coated. Here, particles of the inorganic antimicrobial, such as the ceramic particles, can be incorporated into the powder, blended directly with the powder or applied in a second step to the surface of a powder coated part before the baking step.

Incorporation of the inorganic antimicrobial agent into the powder to be sprayed can be accomplished in any suitable way. For example, it can be done by preparing a master batch concentrate of the resin particles containing the agent particles. That is, the zeolite ceramic particles are also made in a base resin, such as polyethylene, polyurethane, etc. These resin particles containing the zeolite ceramic, are then blended into the polymer or coating material, such as by kneading or rolling to form pellets having the agent in a desired concentration. This preferably is between 0.1 to 30% by weight, preferably 0.5 to 15%, and most preferably 1 to 10% of the pellets. The size of the resin containing zeolite particles in the pellets preferably is about 1.0 micron. The pellets are then ground or melt atomized to produce a powder that is used directly in the spray powder coating process. Also, the mixture can be diluted with untreated powder normally used in the conventional powder coating process. An illustration of a metal stent that is powder coated follows.

4. Metal stent that is powder coated:

stent material	NiTi, stainless steel, Ti-Nb-Zn, tungsten, tantalum
powder	silica
agent	0.1 to 5.0 wt% Ag in zeolite
wt% of zeolite in powder	0.1 to 100.0, more preferably 0.5 to 75.0 and most preferably 1.0 to 50.0 of agent in the powder for coating
size of agent particles	1.0 micron

An alternate method is to combine untreated polymer powder with a solution of an appropriate solvent, with or without a binder, and particles of the inorganic antimicrobial to coat the polymer powder particles with the inorganic antimicrobial agent particle. The solvent is then evaporated and the resulting powder composite is used in the conventional powder coating process ensuring that the inorganic antimicrobial is exposed at the surface. Here, the particle size of the ceramic resin particles of the agent also preferably is about 1.0 micron nominal diameter.

Another method of producing an antimicrobial powder coating is to apply a polymer powder in the conventional manner to the stent surface or surfaces and then apply particles of the inorganic antimicrobial agent in a solvent or water. The stent is then dried and, as in the conventional powder coating process, the inorganic antimicrobial agent is incorporated onto the surface of the coating. Here, the size of the particles of the agent is preferably from about 0.8 to 2.0 microns nominal diameter.

In all of the above coating processes for both the metal and resin type stents, the inorganic antimicrobial agent is present on one or both of the stent surface to perform the intended function of killing bacteria.

Polymeric Stent With Agent - As explained with respect to Figs. 2 and 3, the stent can be of a polymeric material that is prepared from a

suitable resin mixture containing the agent. Here, the agent is automatically available on both surfaces of the stent.

These resins with the agent can be prepared by first preparing a master batch concentrate of the antimicrobial agent. That is, particles of the ceramic zeolite in the resin base are blended with a polymeric resin, such as by kneading or molding. This master batch material is formed into pellets, which can be ground to any desired size. Methods for incorporating the antibiotic agent in the resin are described in U.S. Patents Nos. 4,938,955 and 4,906,464. Final formation of the stents from the resin incorporating the antimicrobial agent can be by compression molding or other conventional forming methods.

The pellets of the master batch material is then added to untreated resin that is to be used to make the stent. The composite of the master batch and untreated resin preferably results in a final concentration by weight of between 0.1 to 30%, preferably 0.5 to 15%, most preferably 1 to 10% of the agent zeolite particles. An example of a polymeric stent follows.

5. Polymeric stent:

resin	polyurethane, polyvinylchloride, silicone rubber
agent	Ag in zeolite (AJ10N Shinagawa)
wt%	0.1 to 20.0, more preferably 0.5 to 10.0 and most preferably 0.5 to 5.0 of agent in the resin of the stent
size of agent particles	1.0 micron

Where polyurethane is to be used as the resin material for the stent, the polyurethane is in liquid form. The zeolite particles, preferably in a base polyurethane resin form but also in the normal ceramic particle state, can be added to untreated polyurethane liquid to make a master batch concentrate, which is then added to untreated polyurethane to make the resin

to be formed into the stent. Alternatively, the zeolite particles in resin form or as the ceramic particles can be added directly into untreated polyurethane. The liquid polyurethane with the particles of the agent are then molded to make the stent. The stent has the agent throughout its entire body and on both surfaces.

The antibiotic particles are preferably present in a concentration by weight in the resin used to make the stent of from 0.01 to 10.0wt%, more preferably from 0.01 to 8.0 wt%, and most preferably from 0.1 to 5.0 wt%. They are present on the surfaces of the stent contacted by the body fluid or body tissue.

A preferred embodiment of the resin with agent for making a polymeric stent has the following constituents:

plastic resin type	polyurethane
material of agent	silver zeolite (preferably Shinagawa type AJ10N)
wt.% of agent in composite of the stent	1.0%
size of the agent particles	0.8 - 25.0 microns

While specific amounts of the antimicrobial agent are given for the various types of stents, it should be considered that in each case that there is an amount of the agent that is sufficient to produce an effective concentration. This means that there is a sufficient amount of the antimicrobial agent used alone, added to or combined with other materials such as to prevent or inhibit the growth of bacterial and/or fungal organisms or to kill such organisms in the particular stent application. The amount of the agent will vary based on the specific agent used and the material with which it is mixed or added to and upon known factors such as type and use of the stent. Environmental factors such as body temperature also should be taken into consideration. It is within the ability of one skilled in the art to

relatively easily determine an effective amount of the antimicrobial agent to be used with each material.

As to the inorganic antimicrobial agent incorporated in the resin for the stent, into the liquid coating material or used in the coating powder, a number of metal ions, which are inorganic materials, have been shown to possess antibiotic activity, including silver, copper, zinc, mercury, tin, lead, bismuth, cadmium, chromium and thallium ions. These antibiotic metal ions are believed to exert their effects by disrupting respiration and electron transport systems upon absorption into bacterial or fungal cells. Antimicrobial metal ions (cations) of silver, gold, copper and zinc, in particular, are considered safe even for *in vivo* use. Antimicrobial silver cations are particularly useful for *in vivo* use due to the fact that they are not substantially absorbed into the body. That is, if such materials are used they should pose no hazard.

In one embodiment of the invention, the inorganic antibiotic metal containing composition is an antibiotic metal salt. Such salts include silver acetate, silver benzoate, silver carbonate, silver ionate, silver iodide, silver lactate, silver laureate, silver nitrate, silver oxide, silver palpitate, silver protein, and silver sulfadiazine. Silver nitrate is preferred. These salts are particularly quick acting, as no release from ceramic particles is necessary to function antimicrobially.

Antibiotic ceramic particles useful with the present invention include zeolites, hydroxy apatite, zirconium phosphates or other ion-exchange ceramics. Zeolites are preferred, and are described in the preferred embodiments referred to below. Hydroxy apatite particles containing antimicrobial metals are described, e.g., in U.S. Patent No. 5,009,898. Zirconium phosphates containing antimicrobial metals are described, e.g., in U.S. Patent Nos. 5,296,238; 5,441,717; and 5,405,644.

Inorganic particles, such as the oxides of titanium, aluminum, zinc and copper, may be coated with a composition which confers antimicrobial properties, for example, by releasing antimicrobial metal ions

such as silver ions, which are described, e.g., in U.S. Patent No. 5,180,585. Inorganic soluble glass particles containing antimicrobial metal ions, such as silver, are described, e.g., in U.S. Patent Nos. 5,766,611 and 5,290,544.

Antibiotic zeolites are preferred. These have been prepared by replacing all or part of the ion-exchangeable ions in zeolite with ammonium ions and antibiotic metal ions, as described in U.S. Patent Nos. 4,938,958 and 4,911,898. Such zeolites have been incorporated in antibiotic resins (as shown in U.S. Patent Nos. 4,938,955 and 4,906,464) and polymer articles (U.S. Patent No. 4,775,585). Polymers including the antibiotic zeolites have been used to make refrigerators, dish washers, rice cookers, plastic film, chopping boards, vacuum bottles, plastic pails, and garbage containers. Other materials in which antibiotic zeolites have been incorporated include flooring, wall paper, cloth, paint, napkins, plastic automobile parts, catheters, bicycles, pens, toys, sand, and concrete. Examples of such uses are described in US Patents 5,714,445; 5,697,203; 5,562,872; 5,180,585; 5,714,430; and 5,102,401. These applications involve slow release of antibiotic silver from the zeolite particles.

Antibiotic zeolites are well-known and can be prepared for use in the present invention using known methods. These include the antibiotic zeolites disclosed, for example, in U.S. Patent Nos. 4,938,958 and 4,911,898.

Either natural zeolites or synthetic zeolites can be used to make the antibiotic zeolites used in the present invention. "Zeolite" is an aluminosilicate having a three dimensional skeletal structure that is represented by the formula: $XM_{2/n}O\text{-}Al_2O_3\text{-}YSiO_2\text{-}ZH_2O$. M represents an ion-exchangeable ion, generally a monovalent or divalent metal ion, n represents the atomic valency of the (metal) ion, X and Y represent coefficients of metal oxide and silica respectively, and Z represents the number of waters of crystallization. Examples of such zeolites include A-type zeolites, X-type zeolites, Y-type zeolites, T-type zeolites, high-silica zeolites, sodalite, mordenite, analcite, clinoptilolite, chabazite and erionite. The present

invention is not restricted to use of these specific zeolites.

The ion-exchange capacities of these zeolites are as follows: A-type zeolite = 7 meq/g; X-type zeolite = 6.4 meq/g; Y-type zeolite = 5 meq/g; T-type zeolite = 3.4 meq/g; sodalite = 11.5 meq/g; mordenite = 2.6 meq/g; analcite = 5 meq/g; clinoptilolite = 2.6 meq/g; chabazite = 5 meq/g; and erionite = 3.8 meq/g. These ion-exchange capacities are sufficient for the zeolites to undergo ion-exchange with ammonium and antibiotic metal ions.

The specific surface area of preferred zeolite particles is preferably at least 150 m^2/g (anhydrous zeolite as standard) and the SiO_2/Al_2O_3 mol ratio in the zeolite composition is preferably less than 14, more preferably less than 11.

The antibiotic metal ions (cations) used in the antibiotic zeolites should be retained on the zeolite particles through an ion-exchange reaction. Antibiotic metal ions which are adsorbed or attached without an ion-exchange reaction exhibit a decreased bactericidal effect and their antibiotic effect is not long-lasting. Nevertheless, it is advantageous for imparting quick antimicrobial action to maintain a sufficient amount of surface adsorbed metal ion.

In the ion-exchange process, the antibiotic metal ions tend to be converted into their oxides, hydroxides, basic salts etc. either in the micropores or on the surfaces of the zeolite and also tend to deposit there, particularly when the concentration of metal ions in the vicinity of the zeolite surface is high. Such deposition tends to adversely affect the bactericidal properties of ion-exchanged zeolite.

In an embodiment of the antibiotic zeolites, a relatively low degree of ion exchange is employed to obtain superior bactericidal properties. It is believed to be required that at least a portion of the zeolite particles retain metal ions having bactericidal properties at ion-exchangeable sites of the zeolite in an amount less than the ion-exchange saturation capacity of the zeolite. In one embodiment, the zeolite employed in the present invention

retains antimicrobial metal ions in an amount up to 41% of the theoretical ion-exchange capacity of the zeolite. Such ion-exchanged zeolite with a relatively low degree of ion-exchange may be prepared by performing ion-exchange using a metal ion solution having a low concentration as compared with solutions conventionally used for ion exchange.

The antibiotic metal ion is preferably present in the range of from about 0.1 to 20.0 wt.% of the zeolite. In one embodiment, the zeolite contains from 0.1 to 20.0 wt.% of silver ions and from 0.1 to 20.0 wt.% of copper or zinc ions. Although ammonium ion can be contained in the zeolite at a concentration of about 20.0 wt.% or less of the zeolite, it is desirable to limit the content of ammonium ions to from 0.5 to 15.0 wt.%, preferably 1.5 to 5.0 wt.%. Weight% described herein is determined for materials dried at temperatures such as 110°C, 250°C or 550°C as this is the temperature employed for the preferred post-manufacturing drying process.

A preferred antibiotic zeolite is type A zeolite containing either a combination of ion-exchanged silver, zinc, and ammonium or silver and ammonium. One such zeolite is manufactured by Shinagawa, Inc. under the product number AW-10N and consists of 0.6% by weight of silver ion-exchanged in Type A zeolite particles having a diameter of about 2.5μ. Another formulation, AJ-10N, consists of about 2% by weight silver ion-exchanged in Type A zeolite particles having a diameter of about 2.5μ. Another formulation, AW-80, contains 0.6% by weight of silver ion-exchanged in Type A zeolite particles having a diameter of about 1.0μ. Another formulation, AJ-80N, consists of about 2% by weight silver ion-exchanged in Type A zeolite particles having a diameter of about 1.0μ. These zeolites preferably contain about between 0.5% and 2.5% by weight of ion-exchanged ammonium. Other formulations also are available.

The zeolites are often obtained in master batches of low density polyethylene, polypropylene, or polystyrene, containing about 20.0 wt.% of the zeolite. Thus, they can be easily mixed with the resins used as materials for forming the composite resin used to make the stent or in the liquid coating

material.

The antibiotic properties of the antibiotic zeolite particles of the invention may be assayed while in aqueous formulations using conventional assay techniques, including for example determining the minimum growth inhibitory concentration (MIC) with respect to a variety of bacteria, eumycetes and yeast. In such a test, the bacteria listed below may be employed: such a test, the bacteria listed below may be employed:

Bacillus cereus varmycoides;
Escherichia coli;
Pseudomonas aeruginosa;
Staphylococcus aureus;
Streptococcus faecalis;
Aspergillus niger;
Aureobasiduim pullulans;
Chaetomium globosum;
Gliocladium virens;
Penicillum funiculosum;
Candida albicans; and
Saccharomyces cerevisiae.

The assay for determining MIC can be carried out by smearing a solution containing bacteria for inoculation onto a plate culture medium to which a test sample of the encapsulated antibiotic zeolite particles is added in a particular concentration, followed by incubation and culturing of the plate. The MIC is defined as a minimum concentration thereof required for inhibiting the growth of each bacteria.

Safety and biocompatibility tests were conducted on the antibiotic zeolites employed in the invention. ISO 10993-1 procedures were employed. The following results were obtained:

Cytotoxicity: **Non-Toxic**
Acute Systemic Toxicity: **Non-Toxic**
Oral Toxicity: Safer than table salt
Intracutaneous Toxicity: **Passed**
Skin Irritation Test: **Non-Irritant**
Chronic Toxicity: **No Observable Effect**
In-vitro Hemolysis: **Non-Hemolytic**
30-day Muscle Implant Test: **Passed**
60-day Muscle Implant Test: **Passed**
90-day Muscle Implant Test: **Passed**
Ames Mutagenicity Test: **Passed**
Pyrogenicity: Non-Pyrogenic

Thus, the antibiotic zeolites are exceptionally suitable under relevant toxicity and biocompatibility standards for use in the stents.

Specific features of the invention are shown in one or more of the drawings for convenience only, as each feature may be combined with other features in accordance with the invention. Alternative embodiments will be recognized by those skilled in the art and are intended to be included within the scope of the claims. All patent applications, patents, patent publications, and literature references cited in this specification are hereby incorporated by reference in their entirety. In the case of inconsistencies, the present description, including definitions, is intended to control. Accordingly, the above description should be construed as illustrating and not limiting the scope of the invention. All such obvious changes and modifications are within the patented scope of the appended claims.

Claims

We Claim:

1. A medical stent comprising a metal, said stent having at least one surface which is to be contacted by body tissue or body fluid wherein said surface is coated with a composition containing antimicrobial zeolite particles.

2. The medical stent of claim 1, wherein said metal is selected from the group consisting of stainless steel, NiTi, tungsten, Ti-Nb-Zr alloy and tantalum.

3. The medical stent of claim 1 wherein said zeolite particles comprise from 0.5 to 75.0 wt. % of said composition.

4. The medical stent of claim 3 wherein said zeolite particles comprise from 0.1 to 20.0 wt. % of the resin stent.

5. The medical stent of claim 1 wherein said composition comprises a polymeric resin.

6. The medical stent of claim 5, wherein said polymeric resin is selected from the group consisting of hydrophilic polyurethane and silicone rubber adhesives.

7. The medical stent of claim 1, wherein said composition is coated on each of the inner and outer surfaces of said stent.

8. The medical stent of claim 1, wherein said antimicrobial zeolite particles comprise antimicrobial metal cations.

9. The medical stent of claim 7 wherein said antimicrobial metal ions are silver ions present in the form of a silver salt.

10. The medical stent of claim 1 wherein said zeolite particles are from 0.5 to 2.5 microns.

11. A medical stent comprising a polymeric resin, and antimicrobial zeolite particles, said stent having at least one surface which is to be contacted by body tissue or body fluid.

12. The medical stent of claim 11, wherein said zeolite particles are coated on at least one surface of said stent.

13. The medical stent of claim 11, wherein said polymeric resin is selected from the group consisting of polyurethane and polyvinyl chloride.

14. A medical stent comprising a metal, said stent having at least one surface which is to be contacted by body tissue or body fluid wherein said surface is coated with a composition which comprises a coating containing an inorganic antimicrobial agent.

15. The stent of claim 14, wherein said antimicrobial agent contains silver cations as the active ingredient.

16. The sten of claim 14, wherein said antimicrobial agent comprises a ceramic carrier.

17. A medical stent comprising a polymeric resin, and an inorganic antimicrobial agent, said stent having at least one surface which is to be contacted by body tissue or body fluid.

18. The stent of claim 17, wherein said antimicrobial agent contains silver cations as the active ingredient.

19. The sten of claim 17, wherein said antimicrobial agent comprises a ceramic carrier.

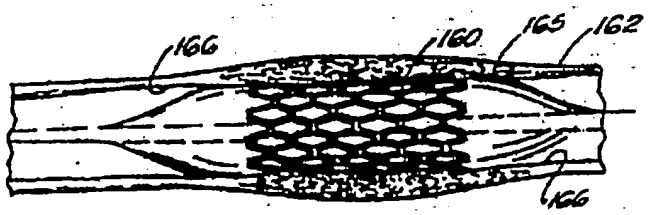

FIGURE 1

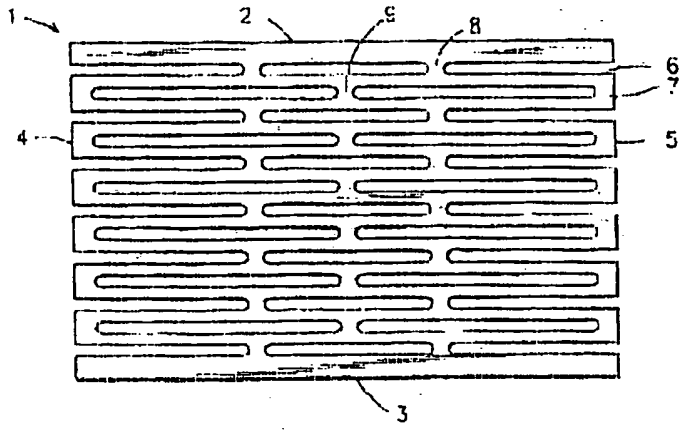

FIGURE 2

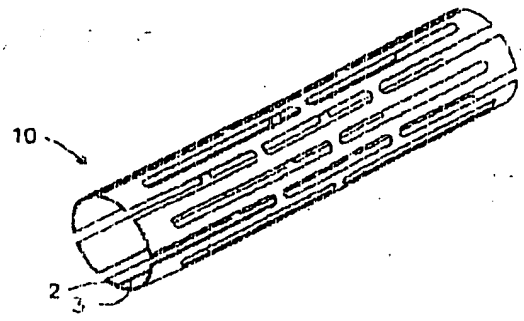

FIGURE 3

INTERNATIONAL SEARCH REPORT

Inter. nal Application No
PCT/US 00/11092

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61L31/02 A61L31/08 A61L31/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61L C01B C08K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 31709 A (UNIV NEW YORK) 4 September 1997 (1997-09-04) page 9, line 18 - line 20 page 15, line 34 claims	1,3-19
Y	US 5 690 670 A (DAVIDSON JAMES A) 25 November 1997 (1997-11-25) cited in the application claims	1,2,7-9, 11,12, 14-19
Y	EP 0 301 717 A (MAEDA KARO) 1 February 1989 (1989-02-01) claims	1,2,7-9, 11,12, 14-19

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 August 2000	05/09/2000

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